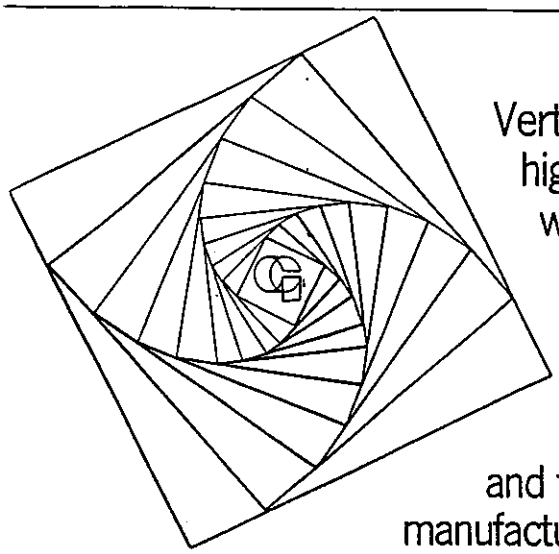
VERTEC. The high technology glass of Glaverbel.

1 of 4 pages

SODA LIME GLASS



Vertec, Glaverbel's high technology glass, is without doubt your best choice for technical applications.

Thanks to the advanced technology and the flexibility of the manufacturing equipment, the company's know-how, the quality-control procedures, we are able to offer Vertec in a full range of thicknesses and to satisfy the most varied requirements, both in quality and quantity.

MECHANICAL PROPERTIES

- **Specific weight:** 2,483 g/cm^3
- **Mean linear coefficient of thermal expansion**

Measured with the dilatometer, this value expresses the expansivity of the material; it is the increase in length of the specimen divided by the original length when heated over the considered temperature interval;

0 to 100° C. :	7.87 10^{-6} per ° C. or ° K.
0 to 200	: 8.09
0 to 300	: 8.36
0 to 400	: 8.70
0 to 500	: 9.15

- **Coefficient of elasticity for tension or Young's Modulus**

The constant of proportionality for stress and strain is a characteristic property of the substance.

E = 7.10^3 kg/mm2 = 7.10^5 bars
E = 68,5 10^9 Pascals or Newtons/m2

- **Poisson's ratio:** 0,22

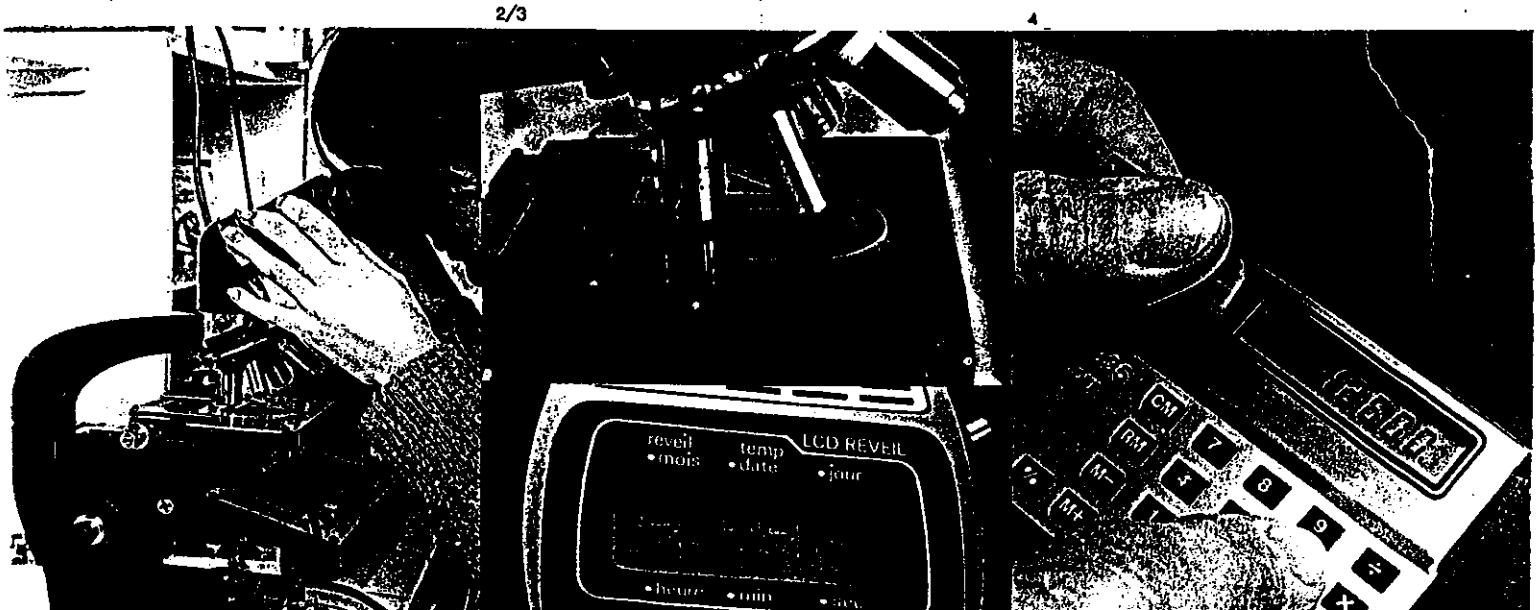
This is the ratio of contraction per unit breadth to longitudinal extension per unit length under unidirectional stress.

CHEMICAL ANALYSIS Composition: typical percentage

SiO_2: 72,0 - Na_2O: 14,0 - K_2O: 0,6 - CaO: 7,1 - MgO: 4,0 - Al_2O_3: 1,9 - Fe_2O_3: 0,1 - SO_3: 0,3

2/3

4



• **Hardness**

Indentation with a diamond pyramid under specific load

Vickers scale: 625 kg/mm2 ± 25

Knoop scale: 585 kg/mm2 ± 20

Ability of a substance to abrade a softer one: Moh's scale: 6 to 7, between orthoclase and quartz.

• **Glass strength**

Glass is classified as a brittle substance because it does not become plastically distorted before breaking.

Glass may be broken in any one many different ways: by tension, compression, twisting or impact; but regardless of the nature of loading, fracture always takes place in tension, resulting from tensile stresses developed by the manner of applying the load.

The factors influencing glass strength are: thickness, condition of glass surface, characteristics of glass edges (clean cut, ground, etc.), size and width to height ratio, frame and glazing.

Glass is most vulnerable along its edges.

Tensile strength of beams, when bending, is between 2 to 4 kg/mm2 for usual conditions of cutting; imperfections along the edges from cutting and handling add to the failure risk and reduces the values of tensile strength. Care will, of course, be taken to produce and maintain edge strength at all stages of the operation: cutting, storing, packing, shipping, unpacking, handling and installation, and final performance must be appreciated when choosing the safety factor.

THERMAL CHARACTERISTICS

In discussing the thermal behaviour of glass, the melting point is not a characteristic temperature so as for crystalline substances; various empirically defined temperatures and particular points on the viscosity-temperature curves, have been proposed to replace this important constant.

• **Annealing range**

To prevent strain in glass, exact control of temperature is important during processing, and especially during an interval - the annealing range - between 480 and 575 °C Above the upper part of the annealing range, the glass is so fluid that it yields practically instantaneously to stress, and a strain cannot persist.

• **Strain point**

The strain point is the temperature from which a piece of glass can be more quickly cooled without introducing permanent strain. The strain point is 490 °C ± 10 with a corresponding viscosity of $10^{14,5}$ poises.

• **Transformation point:** Tg

The transformation point is the temperature at which a sudden change in the coefficient of expansion takes place; the change can be located with fair precision and is a characteristic temperatu for a given glass composition.

The Tg of Vertec is about 535 °C with a viscosity of $10^{13,4}$ poises.

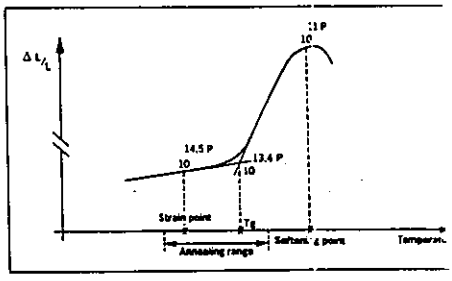
• **Softening point**

The softening point, corresponding to a viscosity of 10^{11} poises, is the maximum point reached on the complete thermal expansion curve for the glass.

The softening point of Vertec is about 575 °C.

• **Littleton point**

For a viscosity of $10^{7,65}$ poises we find the Littleton point: about 720 °C for Vertec (elongation of Vertec under its own weigh at a specific rate).



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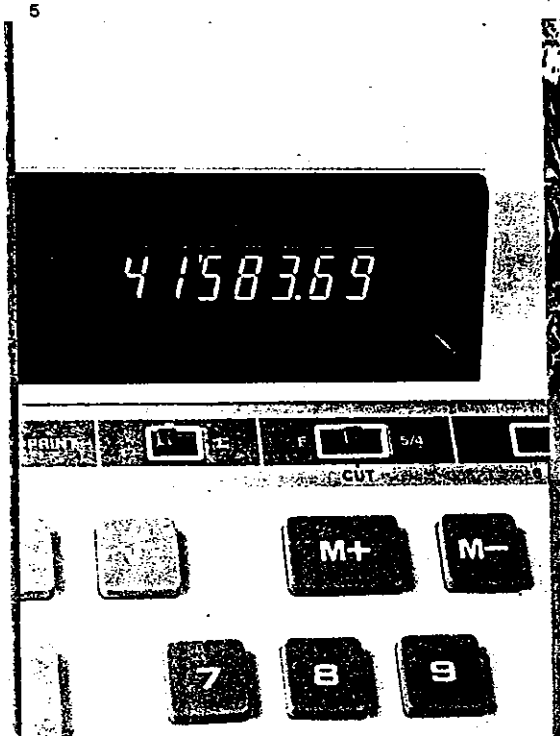

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- **Specific heat:** 0,25 kcal.kg^{-1}.K^{-1}
- **Thermal conductivity** at 20 °C:
0.75 kcal. m/h. m^2.°C = 0,90 W. m./m^2. °C.
- **Heat transfer:** K coefficient:
5.1 kcal/h. m^2. °C = 5.9 W/m^2. °C.

U value: 1.05 Btu/ft^2. F. h.

- **Emissivity factor:**
from 300 mm to 25 μ: 0.9

CHEMICAL CHARACTERISTICS

- **Hydrolytic class**

– according to Standard DIN 12.111: Class 3
– according to Standard ISO 718: Class 3
Once installed for use, glass can withstand large amounts of water without significant surface damage.

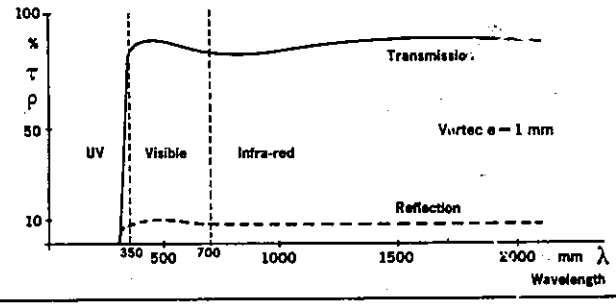
However, water accumulated between lights in storage, even if only a small amount is trapped, can cause surface deterioration.

Storage areas for glass should be maintained at degrees of temperature and humidity that will prevent water vapour condensation on the glass.

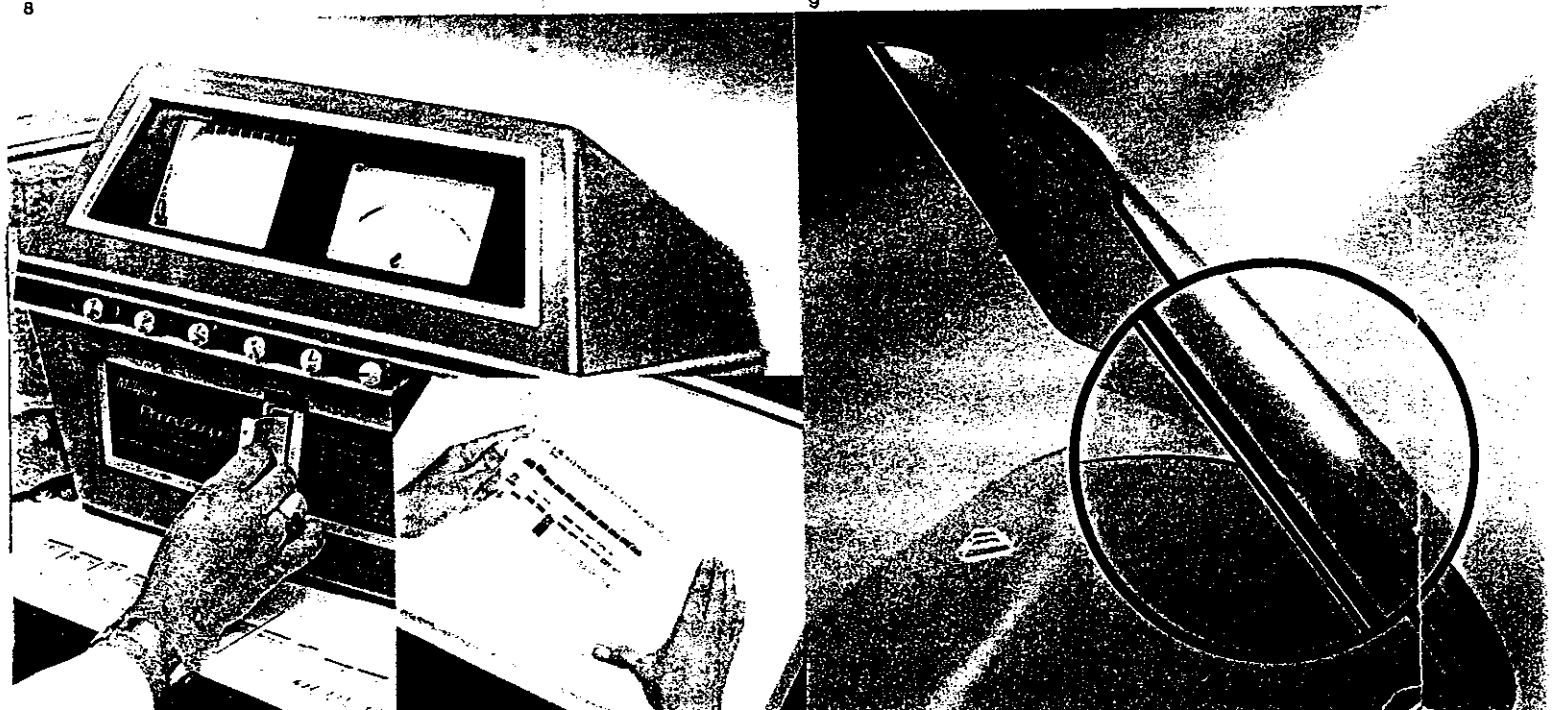
Water and chemicals should not be allowed to harden on glass surfaces because it is always difficult to remove the residues after too long a time.

OPTICAL AND PHOTOMETRIC CHARACTERISTICS

- **Refractive index n:**
from 1.523 to 1.513 for wavelengths between 435 and 645 nm
- **Reflection** : For one face $\rho = (n-1/n+1)^2$
with $\rho = 0.04$ for $n = 1.5$ i.e. reflection is about 8 % for the 2 faces of one sheet of glass.



	Thickness - mm					
	0.4/0.6	0.6/0.8	0.8/1.0	1.0/1.2	1.2/1.4	1.5/1.
Light (375-700 nm)						
Reflection %	8.1	8.1	8.1	8.1	8.1	8.1
Absorption %	0.4	0.5	0.6	0.8	1.0	1.2
Transmission %	91.5	91.4	91.3	91.1	90.9	90.7
Energy (300-2500nm)						
Reflection %	8.0	7.9	7.9	7.8	7.8	7.7
Absorption %	1.3	1.8	2.3	2.8	3.3	4.1
Direct transmission %	90.7	90.3	89.8	89.4	88.9	88.2
Total transmission%	91.0	90.7	90.4	90.0	89.7	89.2



ELECTRICAL CHARACTERISTICS

- **Specific resistivity**
– 1000 Hz 25 °C – log R ohms-cm: 9.7
100 °C: 9.1 - 250 °C: 6.5
– 60 Hz 25 °C: 11
- **Dielectric constant** at 20 °C: 7.75

FLATNESS

When flatness is considered, in order to give a correct expression of this parameter, it is necessary to have a good knowledge of the final use of the glass, the working processes, and the tools which are used for definition and control of this characteristic.

In particular, the size of the sample could be very important; figures are commonly expressed on the basis of a size of 4" x 4"

Of course, in some particular cases, selection of the glass can be considered in order to obtain the desired level of performance.

The parallelism between the two surfaces of a plate with a thickness "e" for a length "l" is expressed by the first differential de/dl which is the deviation of the plate; the second differential de^2/dl^2, which determines the variation of the angle between the two surfaces, is expressed in dioptries.

Typical values are: 1 minute for the angle between faces and 20.10^{-3} dioptries for the optical power.

10/11

CUTTING TOLERANCES

- For very small sizes (about 1"x3") and more than 1000 pcs: + 0/–0,2 mm.
- For sizes up to 250 x 250 mm: ± 0,4 mm.
- For sizes up to 1000 x 1000 mm, various possibilities to discuss.

SIZES

Glass thickness (1) nominal values		Thickness Tolerances (1) ±		Oz.	Usual (2) (3) sizes width/height
mm	inches	mm	inches		mm
0.5	.020	0.1	.004	4	500 x 1140
0.7	.028	0.1	.004	6	600 x 1320
0.9	.035	0.1	.004	7/9	600 x 1400
1.1	.043	0.1	.004	9/11	600 x 1500
1.3	.051	0.1	.004	10/12	800 x 1600
1.6	.063	0.1	.004	12/14	1600 x 2600

(1) Special thicknesses with a minimum tolerance of ± 0,05 (.002 inches) or ± 0,075 (.003 inches) are available on request.
(2) For other sizes please consult us
(3) The sizes are reduced for example when minimum thickness tolerances or special selected characteristics (flatness, surface quality...) are requested.

SOME TYPICAL USES

- Microslides for microscopy and medical uses/cut edges, ground edges, frosted end.
- Anti-Newton (AN) ring glass for the protection of photographic slides.
- Photographic plates.
- Printed circuit substrates and electronic applications.
- Protective glass for pictures, posters, watercolours, pastel drawings, reproductions, engravings, advertisements, maps, diplomas, certificates, etc.
- Meter dials.
- Laminated windshields.
- Mirrors, cosmetic mirrors.
- Special mirrors for solar energy projects.

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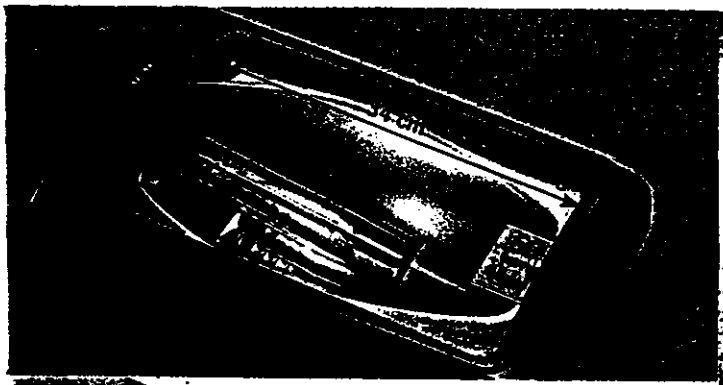
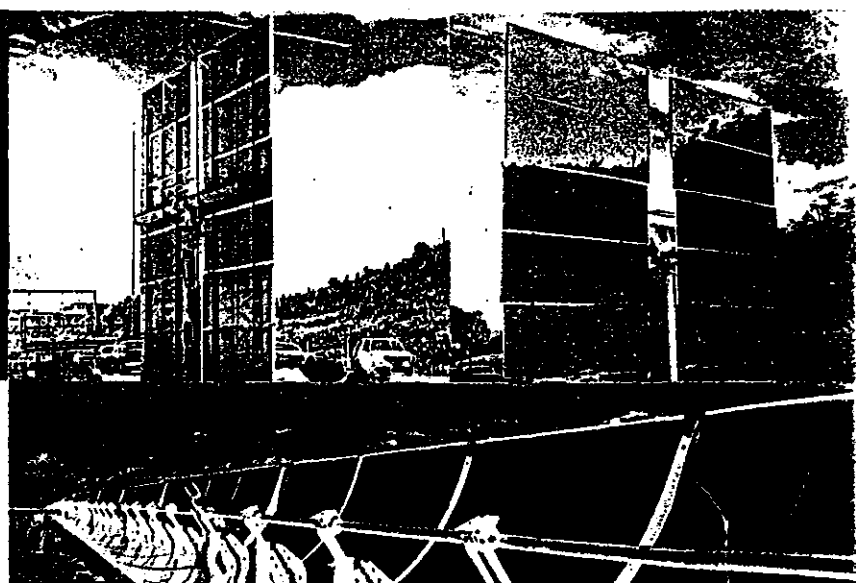




Technical information

CHEMICAL ANALYSIS

- **Composition (typical percentage):**

SiO_2: 70.8% - Na_2O: 13.9% - K_2O: 0.4% - CaO: 8.4%

MgO: 4.4% - Al_2O_3: 1.5% - Fe_2O_3: 0.08% - SO_3: 0.3%

The following properties depend on the composition. The composition may change this to a slight shift in the values given.

MECHANICAL PROPERTIES

- **Specific weight:** 2.49 +/- 0.01 10^3 Kg.m^{-3}
- **Coefficient of elasticity for tension or Young's Modulus**

The constant of proportionality for stress and strain is a characteristic property of the material.

E = 70 +/- 2 GPascals or GN/m^2

- **Poisson's ratio:** 0.23 +/- 0.01

This is the ratio of contraction per-unit breadth to longitudinal extension per-unit length under unidirectional stress.

- **Hardness**

Indentation with a diamond pyramid under a specific load.

Vickers scale (1): 6.35 GPascals or GN/m^2

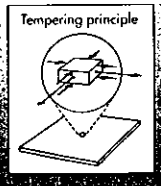
Ability of a substance to abrade a softer one.

Moh's scale: 6.5 +/- 0.5 (between orthoclase and quartz).

- **Glass strength**

Glass is classified as a brittle substance because it does not become plastically distorted before breaking.

Glass may be broken in any one of many different ways: by tension, compression, twisting or impact. Regardless of the nature of loading, fracture always takes place under tension resulting from tensile stresses developed by the manner of applying the load.



The factors influencing glass strength are: thickness, condition of glass surface, characteristics of glass edges (cleancut, ground, etc.), size and width to height ratio, frame and glazing.

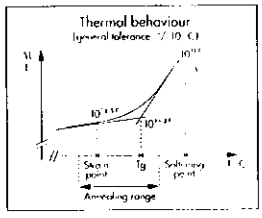
Glass is most vulnerable along its edges.

Tensile strength of beams when bending is between 20 to 40 MPascals or MN/m^2 for usual cutting conditions. Imperfections along the edges from cutting and handling add to the failure risk and reduce the value of the tensile strength. Care must, of course, be taken to produce and maintain edge strength at all

stages of the operation: cutting, storing, packing, shipping, unpacking, handling and installation. Final performance must be considered when choosing the safety factor.

Some industries or applications require strengthened glass. Sodalime glass such as Vertec can be chemically hardened allowing higher tensile strengths (5 x factor typically, up to 300 MPa or MN/m^2).

THERMAL PROPERTIES



In discussing the thermal behaviour of glass, the melting point is not, in contrast to that of crystalline substances, a characteristic temperature. Various empirically defined temperatures and specific points on the viscosity/temperature curves have therefore been proposed to replace this important constant.

- **Annealing range**

To prevent strain in glass, exact control of temperature is important during processing and especially during an interval – the annealing range – between 480 and 585 °C. Above the upper part of the annealing range, the glass is so fluid that it yields practically instantaneously to stress and cannot be strained.

– Strain point

The strain point is the temperature at which a piece of glass can be more quickly cooled without introducing permanent strain. The strain point is 490 °C with a corresponding viscosity of $10^{14.5}$ poises.

– Transformation point : Tg

The transformation point is the temperature at which a sudden change in the coefficient of expansion takes place. The change can be located with fair precision and constitutes a characteristic temperature for a given glass composition. The Tg of Vertec is about 555 °C with a viscosity of $10^{13.4}$ poises.

– Softening point

The softening point, corresponding to a viscosity of about 10^{11} poises, is the maximum point reached on the complete thermal-expansion curve for glass.

The softening point of Vertec is about 585 °C.

– Mean linear coefficient of thermal expansion

Measured with the dilatometer, this value expresses the expansibility of the material. It is the increase in length of the specimen divided by the original length when heated over the considered temperature interval.

MEAN LINEAR COEFFICIENT OF THERMAL EXPANSION		
0 to 100 °C:	8.0 +/- 0.2	10^{-6} per °C or °K
0 to 200 °C:	8.1 +/- 0.2	10^{-6} per °C or °K
0 to 300 °C:	8.4 +/- 0.2	10^{-6} per °C or °K
0 to 400 °C:	8.7 +/- 0.2	10^{-6} per °C or °K
0 to 500 °C:	9.0 +/- 0.2	10^{-6} per °C or °K
A typical value used is 8.5 10^{-6} per °C or °K		

– Specific heat (1): 1 10^{3} $J.Kg^{-1}.°K^{-1}$

– Thermal conductivity (1): 0.95 +/- 0.05 $W.m^{-1}.°K$ @ 20 °C

– Hemispheric Emissivity (1): 0.84

CHEMICAL PROPERTIES

– Hydrolytic class

- according to standard DIN 12.111: class 3
- according to standard ISO 719: class 3

Once installed for use, glass can withstand large amounts of water without significant surface damage. However, water accumulated between panes in storage, even of only a small amount, can cause surface deterioration. Storage areas for glass should be maintained at degrees of temperature and humidity that will prevent water-vapour deposition on the glass. Water and chemicals should not be allowed to harden on glass surfaces because residues are inevitably difficult to remove after too long a time.

OPTICAL AND PHOTOMETRIC PROPERTIES

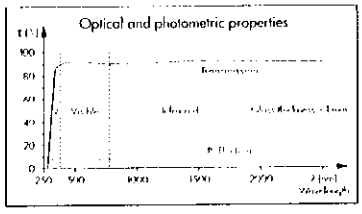
– Refractive index n : 1.52 +/- 0.005 in visible range.

– Reflection : for one face $\rho = \left[\frac{n-1}{n+1}\right]^2$

with $\rho = 0.04$ for $n = 1.5$ i.e. reflection is about 8% for the 2 faces of one sheet of glass.

Example: For the visible range (380 - 780 nm) @ Thickness 1 mm

Reflection 8.1% Absorption 0.8% Transmission 91.1%



ELECTRICAL PROPERTIES

– Specific resistivity

Frequency	@ 1000 Hz	@ 65 Hz
Log R (Ω cm)	25 °C = 9.7 100 °C = 9.1 250 °C = 6.5	25 °C = 11

– Dielectric constant @ 25 °C and 1 MHz: 7.6

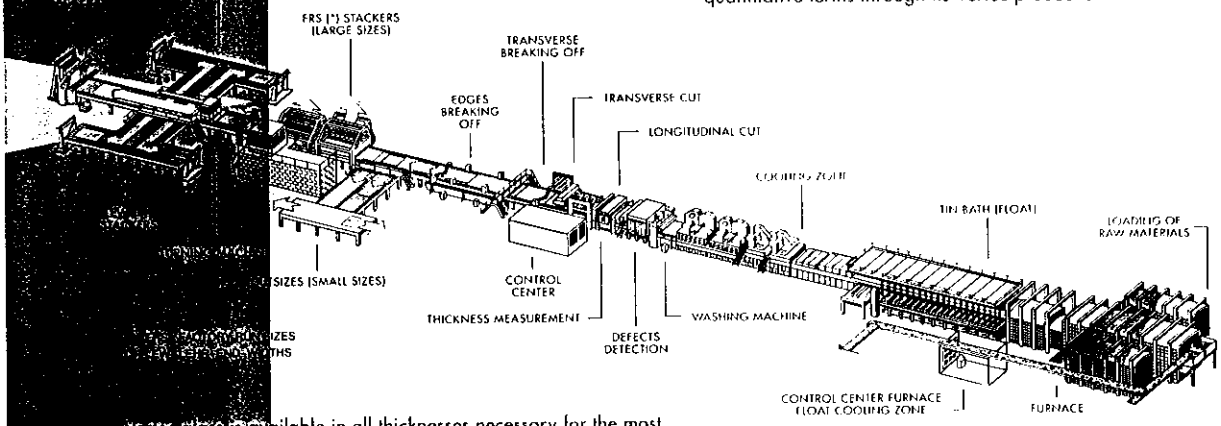
OTHER PROPERTIES

Flatness, parallelism, cutting tolerances, roughness, cosmetic defects, visual inspection ... all conform to the specifications to be agreed between Glaverbel and the customer.

Glaverbel also provides glass products for many applications requiring standard specifications only (e.g. within the picture-frame industry).

Introduction

...ndustry demands high-technology glass products capable of sophisticated performances which adhere to specifications calling for the highest levels of quality standards and quality controls. Glaverbel has responded to these increasingly strict needs in both qualitative and quantitative terms through its Vertec production line.



...ertec glass is available in all thicknesses necessary for the most advanced technical or industrial applications. Indeed, many industries today are calling for ever thinner glass products. Vertec thin and extra-thin float glass has been produced at Mol (Belgium) since 1988 using equipment designed by Glaverbel and continuously updated.

The float process consists of pouring molten glass into a bath of molten metal. The liquid surface of the metal bath and the stability of all the furnace parameters produce consistently high-quality glass, no matter what quantities are produced.

Glaverbel manufactures Vertec sodalime glass in various sizes and thicknesses down to 0.5 mm. The manufacture of thin and extra-thin glass according to the float process guarantees optimal surface evenness, minimal variations in thickness and, within a single batch of glass, lower thickness tolerances than those obtained through any other manufacturing process.

The manufacture of Vertec products involves additional processing steps: glass selection, acid etching, polishing, edge grinding, thermal (proprietary) hardening (proprietary), drilling, passivation (proprietary) and others.

Glaverbel has ... glass and processing steps to develop many Vertec products over the years. Today the Vertec line of high-technology glass products is widely used by industries and various other customers in a growing number of applications: microslides, photographic slide protection, anti-Newton ring glass, chromatographic substrates, substrates for audio/video and pre-formatting stampers, glass mastering, substrates for information storage disks, Liquid Cristal Displays (LCD) manufacturing, picture-framing, non-glare screens and protective screens, cosmetic mirrors, rearview mirrors, photographic mirrors and many others.

If you have an industrial or technical need for sodalime glass, we certainly have the right solution. Glaverbel, the right choice for the customer seeking high performance.

MAIN COMMERCIAL THICKNESSES

0.55 mm	+/- 0.05	0.95 mm	+/- 0.05	1.6 mm	+/- 0.1
0.7 mm	+/- 0.05	1.1 mm	+/- 0.05	1.9 mm	+/- 0.1
0.85 mm	+/- 0.05	1.25 mm	+/- 0.05	2.1 mm	+/- 0.1